PhD SYNOPSIS

An Innovative Cloud Based Digital Health Application integrated with Artificial Intelligence Modules for User – Oriented Medical Nutrition Therapy

Submitted

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INTRODUCTION

Medical Nutrition Therapy (MNT) improves the dietary habits of people and is an important task, which helps to decrease the morbidity and mortality of many chronic diseases and to fight the obesity problem. Personalized nutrition refers to tailored nutritional recommendations aimed at the promotion, maintenance of health and prevention against diseases (1). A balanced diet promotes good health as it provides adequate amounts of energy, proteins, vitamins, minerals, essential fats, micro, and macronutrients for the metabolic needs of the body to function properly at each stage of lifespan. The absence of balanced food and nutrition security leads to health problems such as diabetes, obesity, and malnutrition (2). Education is one of the methods to encourage healthy eating. Mass media, including print media, television, the Internet and software are the educational tools required (3**).** Assessing the current dietary intake and planning nutritious menus for individuals and groups is a complex task that researchers have tried to computerize since the early 1960s (4). If nutritional education is necessary to optimize the diet, it is important that changes in the dietary habit not be drastic. Therefore, providing an optimal intake “range” rather than a single optimal point of intake is more applicable for people (5). The field of mobile health apps is still in a nascent stage and is characterized by a number of limitations, both in terms of sophistication of the apps themselves as well as in knowledge of consumer profiles. Most health apps have not been designed with input from health care and behavior change professionals. A detailed analysis found that among apps classified as "health and fitness" or "medical," only one-fifth offered the possibility of facilitating actual behavioral or physical changes versus non evidence-based gimmicks or simple information provision. Most apps advertised as health related have limited functionality, “do little more than provide information,” and do not offer tracking or data input options (6). App developers need to do more to promote the value and worth of their apps if they are to sustain a viable business model. This will likely necessitate increased openness to partnering with researchers to conduct well-designed trials examining the efficacy of health-directed apps. The state of the evidence for

health apps is significantly lacking (7,8,9), limiting enthusiasm and perceived value among both consumers and healthcare professionals.

With the advent of the big-data era, data specific to consumption of standardized meals, functional food, and beverage sales reports can be extracted. Health informatics enabled initiatives can be applied to conduct data mining and extraction from the electronic health records (EHRs) and insurance claims database. The EHR data can be combined with knowledge derived from nutritional and data sciences to build computational models and synthetic patient cohorts (10,11) aimed to evaluate whether personalized advice caused more changes in dietary behavior as compared to "one size fits all" approach (12). An automated dietary feedback system was used to deliver personalized dietary advice and its comparison with manual systems demonstrated complete agreement (11). The study demonstrated that personalized nutrition advice was more effective compared to population-based nutritional advice.

To derive predictive insights from patient data, one needs to employ data-driven modeling because systems wide advanced computational methods and data analytics platforms can help in the organization, interpretation, and pattern extraction from the health data (13, 14). Similar to the application of AI in interpretation of medical images, the AI technology can be leveraged toward tracking the nutritional contents in the daily meals (15) and the data can be connected to health outcomes measures.

Dietary counseling is getting more important with the rise of lifestyle diseases. It is observed that dietitians are requested to carry out the nutritional assessment, to manually calculate the nutritional needs and to design the everyday meal plan for each patient, which is really time consuming. In most cases, these time-consuming tasks are not completed due to lack of time or inadequate number of personnel. The continuous delivery of high-quality and cost-effective nutritional care to patients has been shown to be an increasingly difficult task. Clinical nutrition research works by practicing dietitians have been restricted due to lack of time in following up the cases, in spite of plenty of options available for the same on Medical Nutrition Therapy. Development of a cloud-based on-line diet consultation module with Artificial Intelligence (AI) incorporated and comparison of its efficacy with one- to-one counseling would be efficiently utilized for client education intervention programs. Cloud based systems will have the ability to

calculate the nutritional requirements and to guide first line nutritional management to patients and clients automatically. The proposed tool can be developed as a mobile app for Mobile devices or a web based application for computers/ handheld devices. Live Chat rooms and FAQ's for quick appraisals can be made available in the application. It helps the user to access information and communication (consultation, BMI calculator, calorie counter, personalized and general diet tips) from anywhere in the world. The proposed solution uses technology to take the service of Dietitians to its targeted users. Evidence based, personalized nutrition services can be offered in authentic manner by creating the application and incorporating AI into it.

The proposed solution wants to harness Information Technology backed by the exponential growth of Mobile phone/ wearable/ hand-held device users in the country to create an alternate platform for diet consultation. It envisions a Digital India where existing human resource and infrastructure restrictions can be overcome by smart solutions. It gives an opportunity to countless qualified dietitians to offer their services from the four walls of their home/ Clinic/ Hospital. Diet Calculator and planner will help the dietitians to plan and cater to the patients efficiently and with error free calculations. It takes out the chances of manual errors normally made during calculations and eliminates human errors. Continuous Clinical nutrition updates in the proposed platform offers best of services and ensures quality consultations. AI in-built constantly upgrades data for the facilitators as well as registered users. Client follow –up and thus effective implementation of achieving qualitative life would be the ultimate goal, so as to make a *'fooducated'* society!

CHAPTER SCHEME

CHAPTER 1 – INTRODUCTION

Introduction to medical nutrition therapy, digital technologies in nutrition education and consultation, scope of cloud based technology and integration of Artificial Intelligence modules to diet consultation applications, need for the study and objectives are discussed in this chapter.

Objectives of the present study

Primary objectives

- Assess preferences of Mobile phone users for on-line diet consultation
- Identify user specific needs for on-line consultation
- Create a database on nutritional ready reckoners for medical nutrition therapy
- Conceptualize, design and execute a cloud based nutrition application medical nutrition therapy
- Integrate AI as a learning tool for studying user preferences in mobile app users
- Apply Artificial Intelligence in identification of the condition based nutritional goal selection.
- Evaluate the efficacy of a cloud based application on clients

Secondary objectives

- Understand the trend in diet consultation pattern toward digital technologies from conventional methods during COVID-19 pandemic
- Describe the scope of digitalized nutrition consultation with applications to emphasize sustainable quality of life to potential users
- Support Clinical Nutritionists in managing effective data management and digital support to users of the application.

CHAPTER II -REVIEW OF LITERATURE

This chapter comprises literature on digital nutrition technologies, mobile app users, cloud computing, artificial intelligence (AI) and scope of novel approaches towards the future especially in the pandemic scenario.

CHAPTER III - METHODOLOGY

The methodology of the study is presented as follows:

I. **Creation of database with nutrition guidelines and customized diet plans**

The database of this tool consists of macronutrient calculations of 1100 recipes. Commonly consumed traditional as well as popular foods in India were included. Primary DB (database) was created using IFCT- Indian Food Composition Table- 2017 (16) as the basis and then nutritive value calculations were added to the master DB of the proposed application, followed by developing the proposed application (with external technical support).

II. **Preliminary survey to assess preference of diet consultation**

The analysis was undertaken to study the preferences and choice of users of hand-held devices towards digital nutrition consultation options when compared with traditional one-to-one consultation patterns. Random sampling method was used to select the samples of the study, with on-line survey using validated questionnaire through Google forms (https://forms.gle/LYAKoYDRhjEK6W7N9) and was sent to maximum possible handheld device users along various digital media platform (WhatsApp and Facebook). Respondents were requested to circulate the Google survey form to maximum possible contacts so as to reach even distant contacts. The study period was for three months and the responses obtained were 1090. The data collected included Age, Gender, Profession, locality, knowledge on healthy diet habits and various preferences for diet consultation methods. Google survey form was made active and open for those who were willing to participate in the study. To rank preferences across all respondents, the details received were consolidated to identify the scoring for each criterion. Statistical analyses included Percentage, Standard deviation and Association (p-value analysis) of the data.

III. **Development of AI integrated cloud based application for effective on-line consultation**

This phase of the study was divided into three sections:

i. **Database integration into Host application on Cloud**

Sections (i) and (ii) were done with the outsourced software developer. Database with nutritive values of more than 1000 commonly consumed traditional and local Indian recipes was done.

Integration of customized menu plans to the application was continued. The application was developed and named as ‘My Dietitian’.

ii. **Development of Mobile User Interface in Android**

Automatic and nutrition requirements are generally employed with tools such as computerized systems, mobile based systems and other such technologies which are more personalized and handy to the users. The wireless infrastructure based devices can collect data for a long period of time. In cloud computing with its immense computation power for easy deployment of healthcare monitoring algorithms and helps to process sensed data. Cloud computing is one of the new approaches in distributed systems that can handle some of the challenges of smart healthcare in terms of security, sharing, integration and management (17).

iii. **Diet consultation tool development**

Clinical nutrition research is an essential endeavor that provides the evidence based underlying dietary requirements and public health messages (18). Early nutritional support in hospitals has resulted in a positive correlation with the patient's outcome (19). General and customized diet plans with different physiological and therapeutic conditions were added to the software to develop diet consultation tools.

IV. **Comparison between off line and on-line diet consultations before and during COVID-19 pandemic (2019 August to 2020 December-16 months)**

In addition to the software updates, an observational study with secondary data analysis was done to understand the choice and trend of people opting for diet consultation services pre and post COVID-19 pandemic. A period of 16 months was selected as the observation period (2019 August to 2020 December). The Clinical Nutrition Department of a multispeciality hospital in Kerala was selected as the area of the study, and the monthly out-patient (OP) statistics for diet consultation services was analyzed.

V. **Customization of User Interface (UI) in mobile app for effective usage**

Cloud based application was developed with database creation of 1100 traditional and commonly used Indian recipes. Integration of Artificial Intelligence (AI) was introduced and the data was hosted to cloud storage, making it accessible from anywhere in the world. App testing was done and bugs were fixed. Evaluation of efficacy of the developed application is being done. Technology & Application platforms currently selected to be used are Google Golang, Angular 5, MySQL, Reds, Docker & Linux.

VI. Efficacy of diet consultation through on-line and off-line platforms to COVID-19 inpatients and non-COVID outpatients

This study aimed to assess the efficacy of diet consultation through on-line and off-line platforms to COVID inpatients and Non-COVID outpatients and to understand the impact of consultation methods on the dietary intake of patients. Retrospective data from a tertiary care multispecialty hospital in central Kerala was collected after obtaining ethical clearance. On-line diet recall of COVID inpatients (n=302, follow up n=277) and Non-COVID outpatients (n=14, follow up n=5) through telephonic, e-mail and WhatsApp and off-line or direct consultation for outpatients (n=298, follow up n=28) was conducted and data collected. ANOVA with a Greenhouse-Geisser correction for Sphericity Assumption, Post hoc tests using the Bonferroni correction, Standard deviation, Significance test using p-value and percentage analyses were the statistical parameters used for the study.

CHAPTER IV - RESULTS AND DISCUSSION

- The findings of the preliminary survey revealed that the opinions collected were positive on the aspect that people require an authenticated diet consultation support as well as a follow up. Even though the first consultation was preferred face-to-face (one-to-one), follow up plans were scored maximum at their convenience, mostly by using smartphones. Consultations at one's own convenient setting would save time and also any reluctance in asking questions to the consultant dietitian, especially on the weight management/ more personalized options. It is found that telephonic consultation scored the least, both for options sought for first hand consultation and also for follow up. More

remarkable approach is attained towards personalized consultations, at one's own privacy.

- In the comparative study with off-line and on-line consultation, achievement of nutrient goal for COVID-19 group was improved even though did not attain the goal due to several other physical and psychological ailments. But the improvement in intake was observed. In the Non-COVID group, lack or long gap of regular follow up in consultation resulted in the lacuna for attaining proposed nutrition intervention goals.
- The results of the efficacy of diet recall before and during COVID pandemic revealed that proper diet consultation and follow up may bring about changes in nutritional status of all categories of patients.
- On-line method was more consistent in follow up when compared to off-line method. During COVID period, patients opting for on-line diet consultation increased. Both COVID-19 inpatients and Non-COVID outpatients who were consistent with on-line follow up were showing significant nutritional changes and those who had off-line consultation lacked regular follow up. Digital health intervention measures have more scope than conventional methods in the current pandemic.

- The developed software features include nutritive value provision of common recipes as incorporated, calorie count from minimum to maximum calories where the user can set the goal, AI enabled chatbot functions, body weight tracking and nutritional planning with general or therapeutic diet plans. The Power BI enabled system helps to tabulate data on a real time basis. At first, information, including personal characteristics such as name, age, sex, weight and height collected through specifically designed User Interface (UI).

CHAPTER V - SUMMARY AND CONCLUSION

- ‘My Dietitian’ has been developed to help make wise and healthy food choices and authenticated diet plans. This software has potential to become an important tool for nutritional evaluation of the dietary adequacy of meals or diets and promotion of healthy eating to the user.

- It has specific considerations for various diseases and options are open to develop more towards this area. Moreover, it can be considered as an educational tool in nutrition.

- AI integration would throw light to analyse the dietary pattern and trends in dietary behaviors of users. Chatbot enables for navigation and quick response to queries.

- Once investigated and confirmed, ‘My Dietitian’ would be an ideal nutritional software to help fill the gaps for therapeutic and lifestyle diet prescriptions.

- It has been designed for a research application, and the purpose is to emphasize the scope of such applications in making digitization changes in clinical nutrition practice.

- The current version of the software has been finalized, and it is flexible for editing databases.

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